

DESCRIPTION

HYDRODYNAMIC BEARING DEVICE

5 TECHNICAL FIELD

The present invention relates to a hydrodynamic bearing device that supports a shaft member to be freely rotatable in a non-contact manner by an action of a dynamic pressure of lubricating oil generated within a radial bearing gap. This hydrodynamic bearing device is suitable for use in a spindle motor for information equipment including magnetic disc devices such as an HDD and an FDD, optical disc devices such as a CD-ROM drive, a CD-R/RW drive, and a DVD-ROM/RAM drive, and magnetooptical disc devices such as an MD drive and an MO drive, a polygon scanner motor of a laser beam printer (LBP), a color wheel for a projector, or a small motor of electric equipment such as an axial fan.

20 BACKGROUND ART

For the aforementioned various motors, improvement of rotational accuracy, increase of an operation speed, reduction of a cost, reduction of noises and the like are needed. One of components that determine those performance requirements is a bearing for supporting a spindle of the

motor. In recent years, the use of a hydrodynamic bearing device having excellent characteristics related to the above performance requirements is studied, or such a hydrodynamic bearing device is actually used.

5           This type of hydrodynamic bearing device includes a radial bearing portion for supporting a shaft member to be freely rotatable in a radial direction and a thrust bearing portion for supporting the shaft member to be freely rotatable in a thrust direction. The radial bearing  
10           portion generates oil film in a radial bearing gap that is formed between an inner circumferential surface of a bearing sleeve and an outer circumferential surface of the shaft member, by an action of a dynamic pressure generated by relative rotation between the shaft member and the  
15           bearing sleeve, thereby supporting the shaft member in the radial direction in a non-contact manner. As the thrust bearing portion, a type which forms oil film in a bearing gap (thrust bearing gap) by an action of a dynamic pressure so as to support the shaft member in a non-contact manner  
20           (this type is called as a hydrodynamic bearing) like the radial bearing portion and a type which supports an end of the shaft member by a thrust plate in a contact manner (this type is called as a pivot bearing) are known.

          According to a conventional technique, the shaft  
25           member used in this type of hydrodynamic pressure bearing

device is fabricated by roughly shaping metal material by a turning process and thereafter grinding the outer circumferential surface of the shaped metal material and the like which require high fabrication accuracy (see  
5 Japanese Patent Laid-Open Publication No. 2002-310159).

In a hydrodynamic bearing device that is incorporated in a spindle motor of a disc device such as an HDD, a member for supporting a disc, e.g., a disc hub, is press fitted and fixed at the tip end of the shaft member. When  
10 the disc hub is press fitted while being inclined, shaft movement in an axial direction increases. Therefore, after the hydrodynamic bearing device is assembled, it is necessary to correct inclination while the movement of the shaft is measured. This correct of inclination increases  
15 the cost of the hydrodynamic bearing device. Moreover, when the disc hub is inclined, the press-fitting force becomes excessively large. Thus, a large load is applied to various portions of the bearing device, so that the decrease of the accuracy, the decrease of strength of a  
20 bonded portion, and the like may be caused.

#### DISCLOSURE OF THE INVENTION

Therefore, it is an object of the present invention to prevent degradation of accuracy and decrease of strength  
25 caused when a hydrodynamic bearing device is assembled and

to reduce a cost of the hydrodynamic bearing device.

As one example of measures for suppressing inclination of a disc hub, it is considered to form a tapered guide face at an end (that is an end from which the disc hub is inserted) of a shaft member. This guide face does not directly affect rotational accuracy of a bearing and the like. Thus, it is not necessary to finish the guide face with high accuracy. Therefore, during grinding of the shaft member, as shown in Fig. 4, it is sufficient that only an outer circumferential surface 21 of the shaft member 20 is ground on a grind stone 30 and the guide face 22 is left in a state in which it is cut by turning but is not ground.

However, when only the outer circumferential surface 21 is ground, a boundary between the outer circumferential surface 21 and the guide face 22 of the shaft member 20 turns into an edge that is called as a pin angle. This edge serves as resistance when the disc hub is press fitted toward the end of the shaft member and is fixed at that end. In order to remove the edge, barreling of the shaft member 20 after the grinding of the outer circumferential surface 21 is considered. However, the barreling may make the ground face rough and may scar the ground face. Therefore, the barreling is not preferable from a viewpoint of the function of the bearing.

Based on the above consideration, according to the present invention, a hydrodynamic bearing device comprises: a shaft member; and a radial bearing portion having a radial bearing gap formed around an outer circumference of the shaft member and supporting the shaft member in a radial direction in a non-contact manner by an action of a dynamic pressure of fluid generated in the radial bearing gap, wherein the shaft member has a guide face serving as a guide when another member is press fitted into the shaft member, and a blunting portion formed between the guide face and the outer circumferential surface of the shaft member adjacent to the guide face, the blunting portion having a shape in which an edge is blunted.

The guide face is formed in a shape in which its diameter is smaller than that of the adjacent outer circumferential surface of the shaft member, for example, a tapered shape having a diameter that becomes smaller upward, from a viewpoint of its function. Although the guide face can be arranged at any location on the shaft member, it is usually arranged at an upper end thereof. One example of the another member that is to be press fitted into the shaft member is a disc hub for holding a disc.

By providing the guide face serving as a guide when the another member is press fitted into the shaft member in the aforementioned manner, the another member is guided by

the tapered guide face of the shaft member while being  
press fitted into the shaft member. Thus, inclination of  
the another member during the press-fitting can be  
suppressed. Moreover, since the blunting portion in which  
5 the edge is blunted is provided between the guide face and  
the outer circumferential surface of the shaft member  
adjacent to the guide face, the guide face and the adjacent  
outer circumferential surface can continue smoothly with no  
edge between them. Thus, press-fitting resistance when the  
10 another member is press fitted can be suppressed, and  
smooth press-fitting of the another member without  
inclination can be achieved. Therefore, improvement of  
accuracy of a motor and cost reduction thereof can be  
achieved. Furthermore, it is possible to prevent damages  
15 of various portions of the bearing device and decrease of  
strength of a bonded portion thereof by application of an  
excessively large press-fitting force.

The guide face, the outer circumferential surface of  
the shaft member that is adjacent to the guide face, and  
20 the blunting portion can be formed by grinding. In this  
case, not only the outer circumferential surface of the  
shaft member but also the blunting portion are finished  
with high accuracy. Therefore, the press-fitting  
resistance can be further reduced.

25 Considering a processing efficiency, it is desirable

that the guide face, the aforementioned outer circumferential surface of the shaft member, and the blunting portion be ground simultaneously.

In order to reduce the press-fitting resistance, it is preferable to make generating lines of the guide face, the outer circumferential surface of the shaft member adjacent to the guide face, and the blunting portion continue as smoothly as possible. In order to achieve such continuity easily, it is desirable to form the blunting portion to have a curved surface.

By forming a motor by the aforementioned hydrodynamic bearing device, a rotor magnet, and a stator coil, the motor suitable for the aforementioned information equipment (a spindle motor, a polygon scanner motor, and other small motors) can be provided.

The hydrodynamic bearing device according to the present invention having: a shaft member; and a radial bearing portion having a radial bearing gap formed around an outer circumference of the shaft member and supporting the shaft member in a radial direction in a non-contact manner by an action of a dynamic pressure of fluid generated in the radial bearing gap, can be manufactured by forming, on the shaft member, a guide face serving as a guide when another member is press fitted into the shaft member and thereafter simultaneously grinding the guide

face, the outer circumferential surface of the shaft member adjacent to the guide face, and a boundary portion between them.

According to the present invention, it is possible to prevent degradation of accuracy and decrease of strength when the hydrodynamic bearing device is assembled. In addition, the cost of the hydrodynamic bearing device can be reduced.

#### 10 BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a vertical cross-sectional view of a spindle motor including a hydrodynamic bearing device of the present invention therein.

Fig. 2 is a vertical cross-sectional view of the above hydrodynamic bearing device.

Fig. 3 is a cross-sectional view in which a process for grinding a shaft member according to the present invention is enlarged.

Fig. 4 is a vertical cross-sectional view in which a comparative example of the grinding process for the shaft member is enlarged.

Fig. 5 is a sectional view of a radial bearing portion in a hydrodynamic bearing device according to another embodiment of the present invention.



## BEST MODE FOR CARRYING OUT THE INVENTION

Preferred embodiments of the present invention will now be described below.

Fig. 1 shows a spindle motor used in a disc drive such as an HDD, as an exemplary motor incorporating a hydrodynamic bearing device therein. The motor includes a hydrodynamic bearing device 1 for supporting a shaft member 2 to be freely rotatable in a non-contact manner, a rotation member 3 (disc hub) attached to the shaft member 2, a stator coil 4 and a rotor magnet 5 that are opposed to each other with a radial gap interposed therebetween, for example, and a bracket 6. The stator coil 4 is attached to an outer circumference of the bracket 6. The rotor magnet 5 is attached to an inner circumference of the disc hub 3. The disc hub 3 is arranged to hold one or more discs D such as magnetic discs, in its outer circumferential portion. When a current flows through the stator coil 4, an exciting force between the stator coil 4 and the rotor magnet 5 rotates the rotor magnet 5. With the rotation of the rotor 5, the disc hub 3 and the shaft member 2 are rotated as a unit.

Fig. 2 shows a first embodiment of the hydrodynamic bearing device 1. This hydrodynamic bearing device 1 according to this embodiment includes a housing 7, a bearing sleeve 8, and a thrust member 10 that are fixed to

the housing 7, and a shaft member 2 inserted into the bearing sleeve.

A first radial bearing portion R1 and a second radial bearing portion R2 are provided between an inner circumferential surface 8a of the bearing sleeve 8 and an outer circumferential surface 2a1 of a shaft portion 2a of the shaft member 2. The first and second radial bearing portions R1 and R2 are arranged to be axially away from each other. Moreover, a first thrust bearing portion T1 is provided between a lower end face 8c of the bearing sleeve 8 and an upper end face 2b1 of a flange portion 2b of the shaft member 2, while a second thrust bearing portion T2 is provided between an end face 10a of the thrust member 10 and a lower end face 2b2 of the flange portion 2b. For convenience of description, the side of the thrust member 10 is assumed to be a lower side and the opposite side is assumed to be an upper side.

The housing 7 is made of a soft metal material such as brass, or a resin material such as a thermoplastic material, for example. In the shown example, the housing 7 includes a cylindrical side portion 7b and an annular seal portion 7a that is formed integrally with the side portion 7b and extends from an upper end of the side portion 7b inward in the radial direction. An inner circumferential surface 7a1 of the seal portion 7a is opposed to a tapered

face 2a2 provided on the outer circumference of the shaft portion 2a with a predetermined seal space S interposed therebetween. The tapered face 2a2 of the shaft portion 2a has a diameter that gradually decreases upward (toward the outside with respect to the housing 7), and serves as a taper seal by rotation of the shaft member 2.

The shaft member 2 is formed by roughly shaping a metal material such as stainless steel by turning, or forging, and then grinding the shaped metal material, for example. The shaft member 2 in the shown example includes the shaft portion 2a and the flange portion 2b provided at a lower end of the shaft portion 2a. The shaft portion 2a and the flange portion 2b are formed and shaped integrally. Alternatively, the shaft portion 2a and the flange portion 2b are formed as separate components. In this case, the shaft member 2 is formed by press fitting the flange portion 2b into the shaft portion 2a.

As shown in Fig. 3, at an upper end of the shaft portion 2a is formed a tapered guide face 2c. A taper angle  $\theta$  of the guide face 2c (angle of inclination with respect to the center of the shaft) is set to fall within a range from about  $5^\circ$  to about  $20^\circ$ . In a boundary portion between the guide face 2c and the outer circumferential surface 2a3 of the shaft member 2 that is adjacent to the guide face 2c (hereinafter, simply referred to as "adjacent

outer circumferential surface"), no edge remains. Instead, a blunting portion 2d having a shape in which an edge is blunted is formed between the guide face 2c and the adjacent outer circumferential surface 2a3. In the present embodiment, the blunting portion 2d has a curved surface having a radius  $r$ , and is smoothly connected with the guide face 2c and the adjacent outer circumferential surface 2a3.

In the present embodiment, the blunting portion 2d is formed and shaped by simultaneously grinding the aforementioned boundary portion, the guide face 2c, and the adjacent outer circumferential surface 2a3. This simultaneous grinding is carried out by using a grind stone 11 having a straight portion 11a corresponding to the adjacent outer circumferential surface 2a3, a tapered portion 11b corresponding to the guide face 2c, and a curved portion 11c corresponding to the blunting portion 2d. The curved portion 11c of the grind stone 11 is formed in a range of  $R0.1$  to  $R0.5$ . The straight portion 11a and the tapered portion 11b of the grind stone 11 are arranged to smoothly continue via the curved portion 11c. By grinding the outer circumference of the shaft member 2 on the aforementioned grind stone 11, the guide face 2c, the blunting portion 2d, and the adjacent outer circumferential surface 2a3 form a continuous plane with no edge.

The bearing sleeve 8 is formed to be cylindrical, for

example, from a porous material formed by sintered metal,  
in particular from a porous material of sintered metal  
mainly containing copper. The bearing sleeve 8 is fixed at  
a predetermined position on the inner circumferential  
5 surface 7c of the housing 7.

On the inner circumferential surface 8a of the  
bearing sleeve 8, two regions, i.e., an upper region and a  
lower region that serve as radial bearing faces of the  
first radial bearing portion R1 and the second radial  
10 bearing portion R2, respectively, are provided to be  
axially away from each other. In each of the two regions,  
a plurality of dynamic pressure generating grooves arranged  
in a herringbone pattern, for example, are formed. On the  
outer circumferential surface 8d of the bearing sleeve 8,  
15 one or more axial grooves 8d1 are formed to extend over the  
entire axial length. The upper end face 8b of the bearing  
sleeve 8 is in contact with an inner side face 7a2 of the  
seal portion 7a in its inner region in the radial direction.

On the lower end face 8c of the bearing sleeve 8 (or  
20 the upper end face 2b1 of the flange portion 2b), which  
serves as a thrust bearing face of the first thrust bearing  
portion T1, a plurality of dynamic pressure generating  
grooves that are spirally arranged, for example, are formed.  
The dynamic pressure generating grooves may be arranged in  
25 a herringbone pattern or in a radial pattern, for example.

The thrust member 10 is formed of a metal material such as brass, or a resin material, for example, and is fixed at a lower end of the inner circumferential surface 7c of the housing 7. On the end face 10a of the thrust member 10 (or the lower end face 2b2 of the flange portion 2b), which serves as a thrust bearing face of the second thrust bearing portion T2, a plurality of dynamic pressure generating grooves arranged in a herringbone pattern, for example, are formed. Those dynamic pressure generating grooves may be arranged spirally or radially, for example.

In assembly of the hydrodynamic bearing device 1 of the present embodiment, first, the bearing sleeve 8 is fixed on the inner circumference of the housing 7 and the shaft portion 2a of the shaft member 2 is inserted into the inner circumference of the bearing sleeve 8. Then, the bottom of the housing 7 is closed and sealed with the thrust member 10, and thereafter an inner space of the housing 7 sealed with the seal portion 7a, including inner pores of the bearing sleeve 8, is filled with a lubricating oil. A surface level of the lubricating oil is kept within a range of the seal space S.

When the shaft member 2 is rotated, the regions (upper and lower regions) of the inner circumferential surface 8a of the bearing sleeve 8 serve as the radial bearing faces and are opposed to the outer circumferential

surface 2a1 of the shaft portion 2a via the radial bearing gaps. Moreover, the region of the lower end face 8c of the bearing sleeve 8 serves as the thrust bearing face, and is opposed to the upper end face 2b1 of the flange portion 2b via the thrust bearing gap, while the region of the end face 10a of the thrust member 10 serves as the thrust bearing face, and is opposed to the lower end face 2b2 of the flange portion 2b via the thrust bearing gap. With the rotation of the shaft member 2, a dynamic pressure of the lubricating oil is generated in the radial bearing gap, so that the shaft portion 2a of the shaft member 2 is supported to be freely rotatable in the radial direction in a non-contact manner by the lubricating oil film formed in the radial bearing gap. Thus, the first radial bearing portion R1 and the second radial bearing portion R2 that support the shaft member 2 to be freely rotatable in the radial direction in a non-contact manner are formed. At the same time, a dynamic pressure of the lubricating oil is also generated in the thrust bearing gap, so that the flange portion 2b of the shaft member 2 is supported to be freely rotatable in both thrust directions in a non-contact manner by the lubricating oil film formed in the thrust bearing gap. In this manner, the first thrust bearing portion T1 and the second thrust bearing portion T2 that support the shaft member 2 to be freely rotatable in the

thrust directions in a non-contact manner are formed.

After completion of the assembly of the  
aforementioned hydrodynamic bearing device 1, when a motor  
is assembled, a disc hub 3 is press fitted into the shaft  
5 member 2 so as to be fixed at the upper end of the shaft  
portion 2a of the shaft member 2. During the press-fitting,  
the guide face 2c provided at the upper end of the shaft  
portion 2 serves as a guide for the disc hub 3 that is  
press fitted. Thus, the disc hub 3 is guided by the  
10 tapered guide face 2c, so that inclination of the disc hub  
3 during the press-fitting can be suppressed. Moreover,  
since the blunting portion 2d having an R shape is provided  
between the guide face 2c and the adjacent outer  
circumferential surface 2a3, press-fitting resistance can  
15 be reduced. Thus, it is possible to smoothly press fit the  
disc hub 3 without inclining it. This can improve the  
accuracy of the hydrodynamic bearing device 1 and reduce  
the cost of the motor. Furthermore, damage of various  
portions of the hydrodynamic bearing device and decrease of  
20 strength of a bonded portion thereof due to the application  
of excess press-fitting force can be also prevented.

In the above embodiment, the thrust bearing portions  
T1 and T2 (see Fig. 2) are formed by non-contact  
hydrodynamic bearings. However, the present invention can  
25 also be applied to another hydrodynamic bearing device (not



shown) in which the radial bearing portions R1 and R2 are formed by hydrodynamic bearings while thrust bearing portions are formed by pivot bearings.

The radial bearing portions R1 and R2 can also be  
5 formed by multi-arc bearings. Fig. 5A shows an example thereof, in which a plurality of arcuate surfaces 8a1 are formed in the areas of the inner peripheral surface 8a of the bearing sleeve 8 constituting the respective radial bearing surfaces of the first radial bearing portion R1 and  
10 the second radial bearing portion R2 (also referred to as the "tapered bearings"). The arcuate surfaces 8a1 are eccentric arcuate surfaces whose centers are offset from the rotation axis O by the same distance, and are formed at equal intervals in the circumferential direction. Between  
15 the eccentric arcuate surfaces 8a1, there are formed axial separation grooves 8a2.

By inserting the shaft portion 2a of the shaft member 2 into the bore defined by the inner peripheral surface 8a of the bearing sleeve 8, the radial bearing gaps of the  
20 first and second radial bearing portions R1 and R2 are formed between the eccentric arcuate surfaces 8a1 and separation grooves 8a2 of the bearing sleeve 8 and the circular outer peripheral surface 2a of the shaft portion 2a. Of the radial bearing gaps, the areas opposed to the  
25 eccentric arcuate surfaces 8a1 constitute wedge-like gaps

8a3 gradually reduced in gap width in one circumferential direction. The width-reducing direction of the wedge-like gaps 8a3 coincides with the rotating direction of the shaft member 2.

5 Figs. 5B and 5C show other embodiments of the multi-arc bearings forming the first and second radial bearing portions R1 and R2.

Of these, in the embodiment shown in Fig. 5B, the construction shown in Fig. 5A is modified such that  
10 predetermined areas  $\theta$  on the minimum gap side of the eccentric arcuate surfaces 8a1 are formed by concentric arcs which have the rotation axis O as their centers. Thus, in each predetermined area  $\theta$ , the radial bearing gap (minimum gap) is fixed. A multi-arc bearing thus  
15 constructed is also referred to as a tapered flat bearing.

In Fig. 5C, the areas of the inner peripheral surface 8a of the bearing sleeve 8 constituting the radial bearing surfaces are formed by three arcuate surfaces 8a1, with the centers of the three arcuate surfaces 8a1 being offset by  
20 the same distance from the rotation axis O. In each of the areas defined by the three eccentric arcuate surfaces 8a1, the radial bearing gap is configured so as to be gradually diminished in both circumferential directions.

While the multi-arc bearings of the first and second  
25 radial bearing portions R1 and R2 are all three-arc

bearings, this should not be construed restrictively; it is also possible to adopt a so-called four-arc bearing, five-arc bearing, or, further, a multi-arc bearing with six arcs or more. Further, apart from the construction in which two radial bearing portions are axially spaced apart from each other as in the case of the radial bearing portions R1 and R2, it is also possible to adopt a construction in which a single radial bearing portion is provided so as to extend over the upper and lower areas of the inner peripheral surface of the bearing sleeve 8.

Further, while in the above embodiment multi-arc bearings are adopted as the radial bearing portions R1 and R2, it is also possible to adopt a bearing of some other type. For example, although not shown, it is also possible to use, in the area of the inner peripheral surface 8a of the bearing sleeve 8 constituting the radial bearing surface, a step bearing in which there are formed dynamic pressure grooves in the form of a plurality of axial grooves.